

# MERLIN

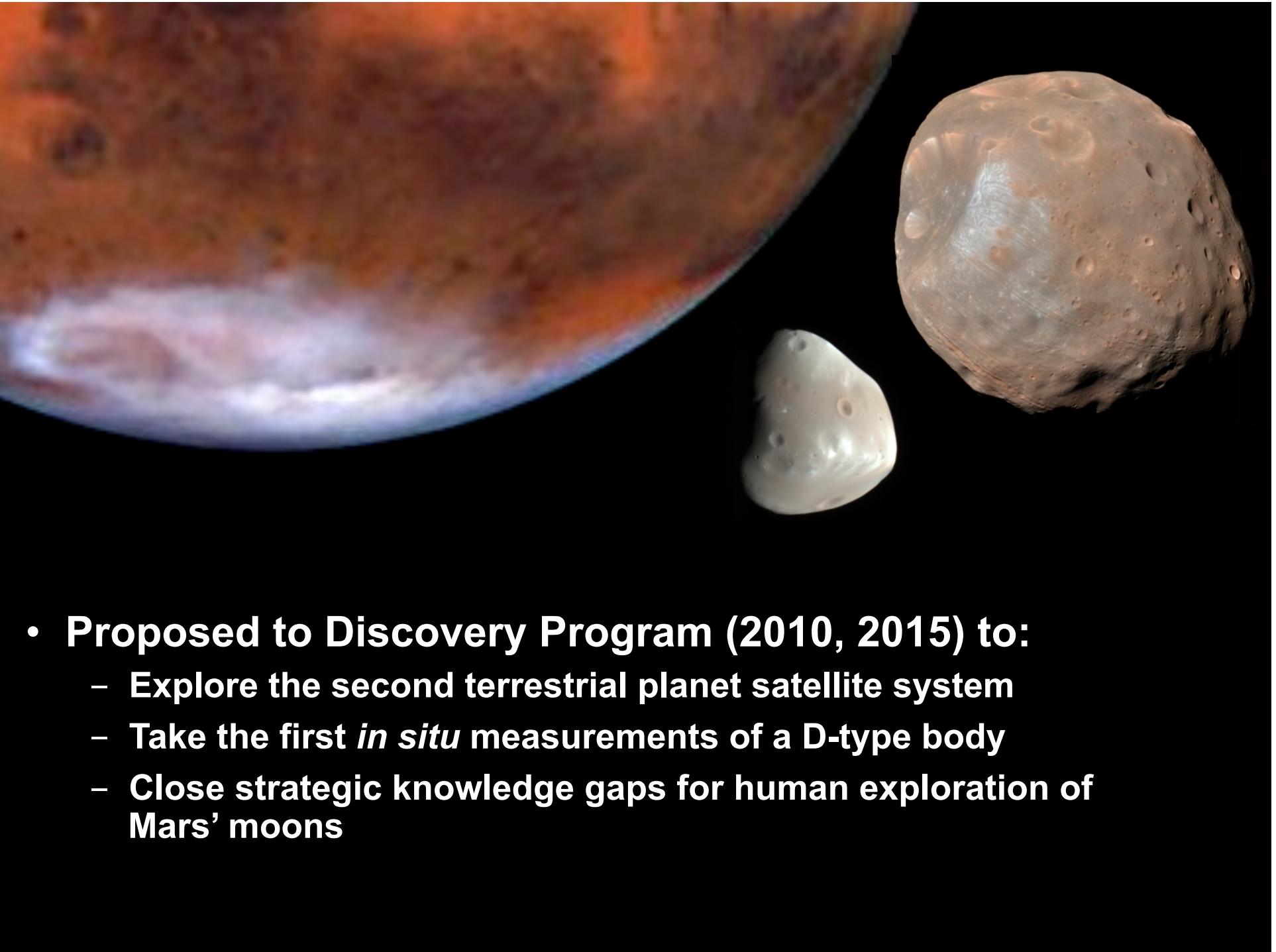
Mars-Moon Exploration, Reconnaissance  
and Landed Investigation



## Mars-Moons Exploration, Reconnaissance, and Landed Investigation

*SSEVI Exploration Science Forum*

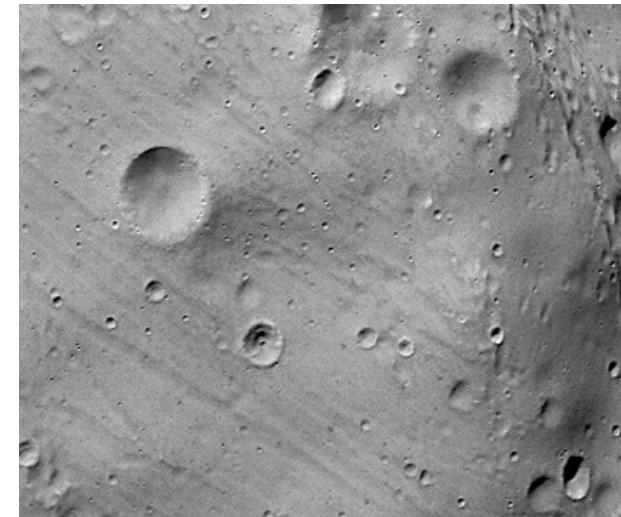
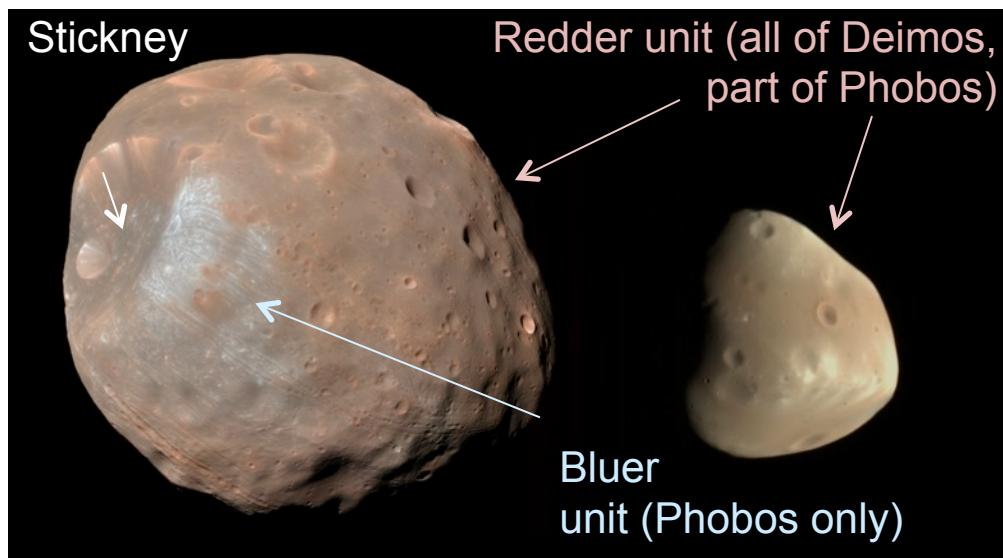
Scott L. Murchie, **Andrew S. Rivkin**, Nancy L. Chabot, Debra L. Buczkowski, Douglas A. Eng,  
Patrick N. Peplowski, Carolyn M. Ernst, Julie C. Castillo-Rogez, Artur B. Chmielewski, Justin N. Maki,  
Ashitey Trebi-Ollenu, Raymond E. Arvidson, Bethany L. Ehlmann, Harlan E. Spence, Mihaly Horanyi,  
Goestar Klingelhoefer, and John A. Christian



- Proposed to Discovery Program (2010, 2015) to:
  - Explore the second terrestrial planet satellite system
  - Take the first *in situ* measurements of a D-type body
  - Close strategic knowledge gaps for human exploration of Mars' moons

# The Other Terrestrial Planet Satellites

- Morphologies & densities indicate different evolutions
- 2 color units:
  - redder unit on both moons
  - bluer unit on Phobos
- Mapping the moons' morphology and color will yield new understanding of small-body geologic processes



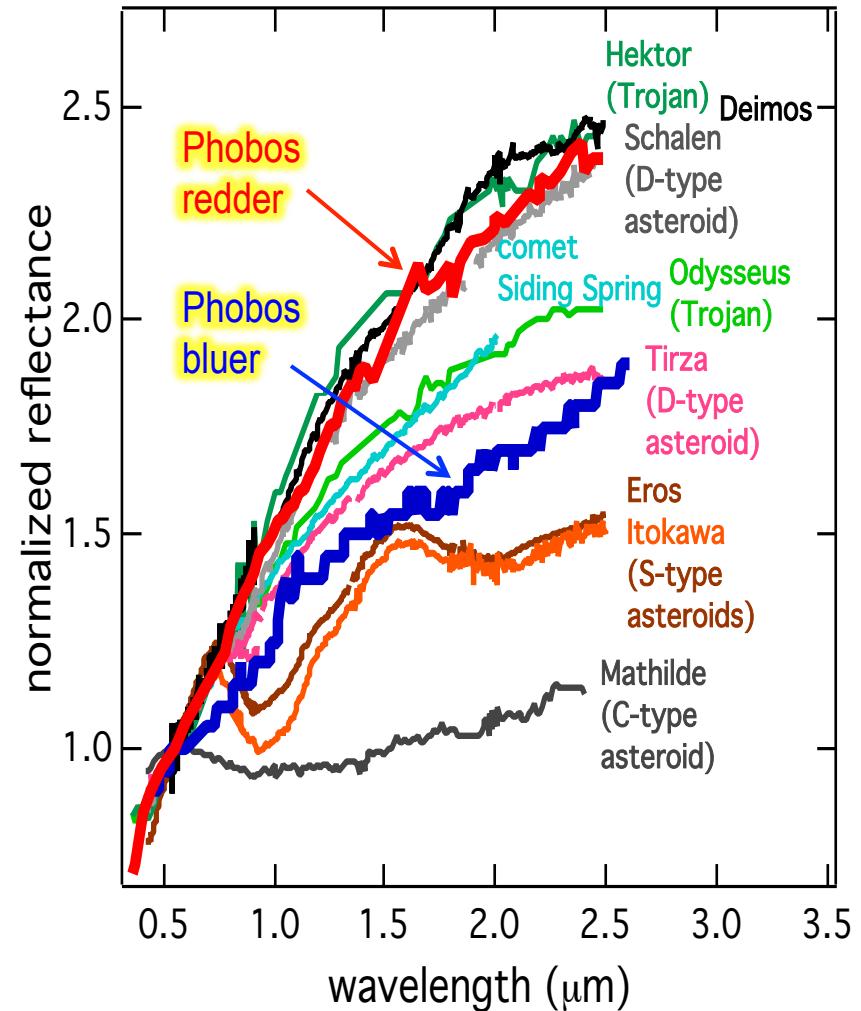
**Phobos:** heavily cratered,  
grooves;  $\rho = 1.87 \pm 0.02 \text{ g/cm}^3$

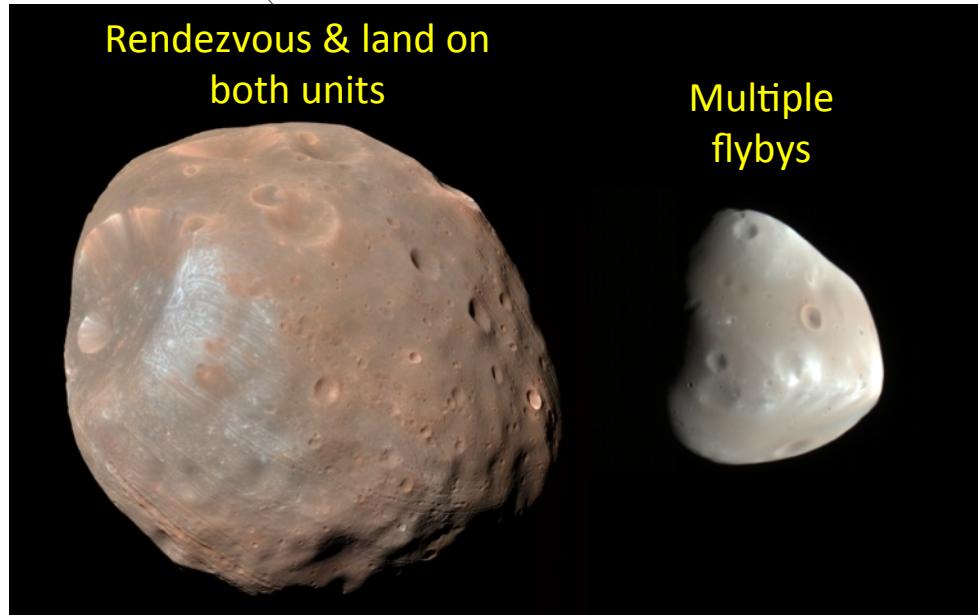


**Deimos:** lightly cratered,  
mantled;  $\rho = 1.49 \pm 0.19 \text{ g/cm}^3$

# *Resemble Outer Solar System Bodies*

- Both are D-type and bracket the range of D-types' spectral variability
- D-types thought to be C-, volatile-rich
- Hypothesis: Phobos and Deimos are captured primitive bodies
- Also could be space-weathered bodies co-accreted with Mars, or reaccreted Mars basin ejecta
- **Determining the moons' compositions constrains their origin, providing insight into early solar system processes**





1. What are the moons' compositions and origins?
2. Are they rich in C and volatiles?
3. What geological processes affect their surfaces and environment?
4. What are the moons' interior structures?

## *Measurements Close Strategic Knowledge Gaps*

- Elemental and mineralogical composition
- C and H for In Site Resource Utilization (ISRU)
- Regolith mechanical properties
- Particulate / radiation environments around Mars
- Moons' shapes and gravity fields

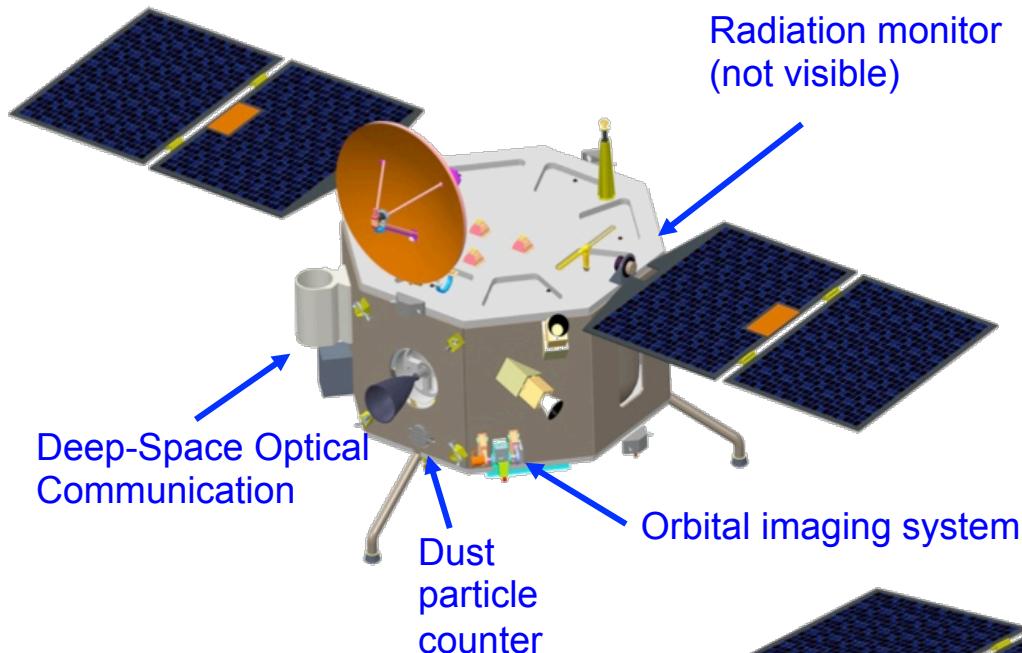
### ***MERLIN science measurements:***

	Elemental composition		Mineralogical composition		Orbital & landed imaging		Radio science		Dust particle counter
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MERLIN Science Questions	Visions and Voyages Questions	MERLIN Addressed Using
Phobos' and Deimos' compositions and origin	Initial stages, conditions, processes of solar system formation	Elemental composition
		Mineral composition
		Spectral heterogeneity
Content, forms of water and carbon	Supply of water to inner planets	Occurrence of hydrated minerals
	Primordial sources organic matter	Abundance of C and H Types, abundances of C phases
Geological processes that affect moons' surfaces and environment	Chemical and physical processes that shaped the solar system over time	Regolith landforms
		Groove formation processes
		Effects of space weathering
		Orbital particulate environment
Interior structures and constraints on origins?		Shape and volume
		Mass and mass distribution

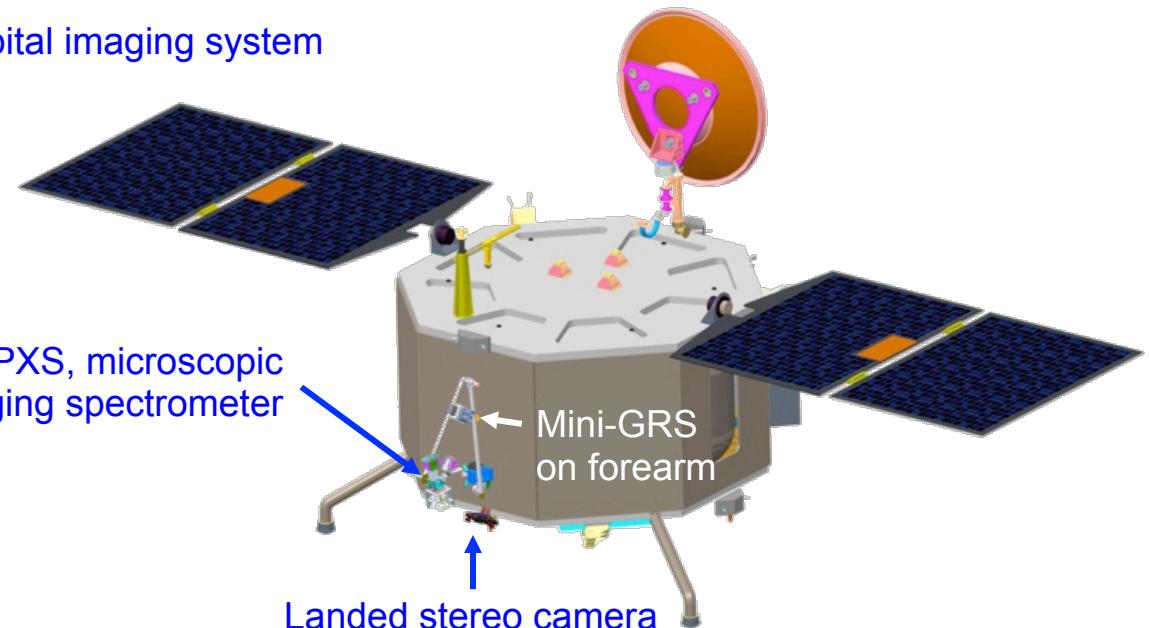
# MERLIN

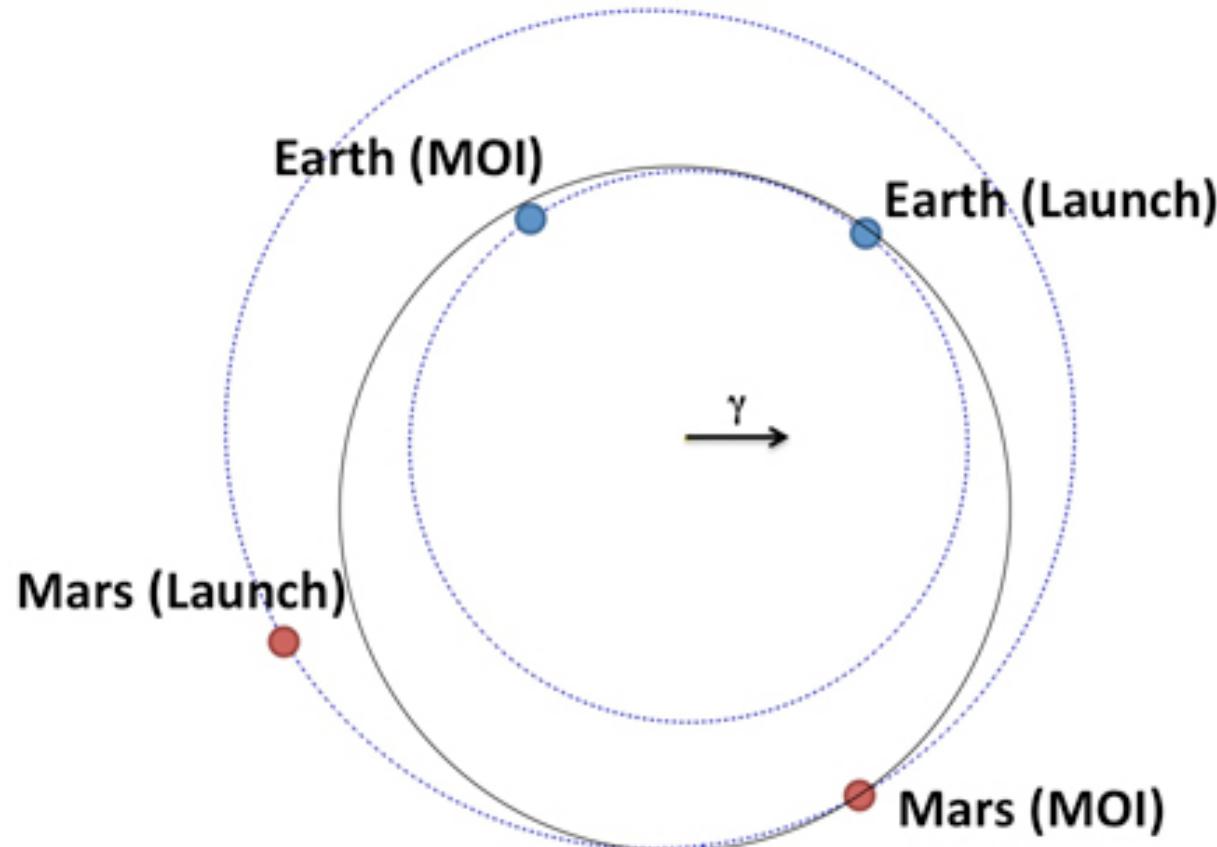
*Orbital instruments*



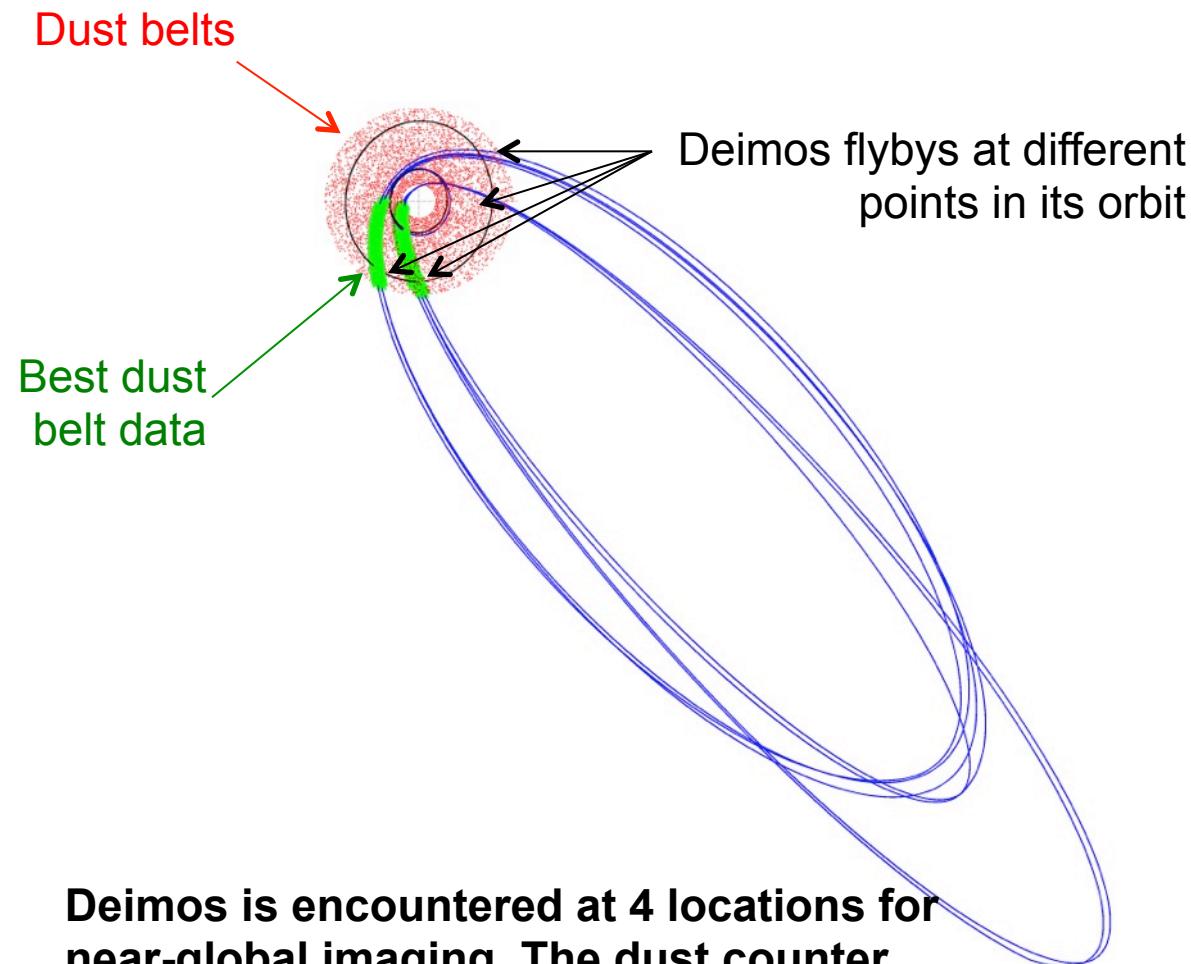
## *Two Views of Spacecraft Show Science & Exploration Payload*

*Robotic arm supports landed science*



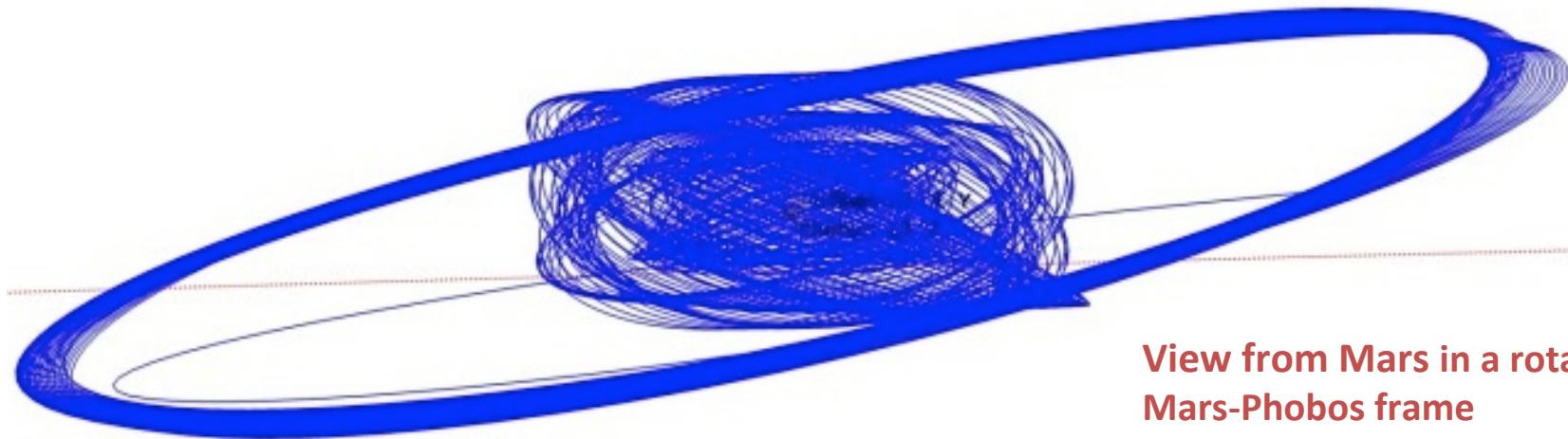
*Mission Profile: Cruise Phase*

**Launch is in Nov 2021 on an Atlas V 401. MOI is in Jan 2024**



**Deimos is encountered at 4 locations for near-global imaging. The dust counter measures Phobos' and Deimos' hypothesized dust belts**

## *Mission Profile: Phobos Rendezvous*



View from Mars in a rotating  
Mars-Phobos frame

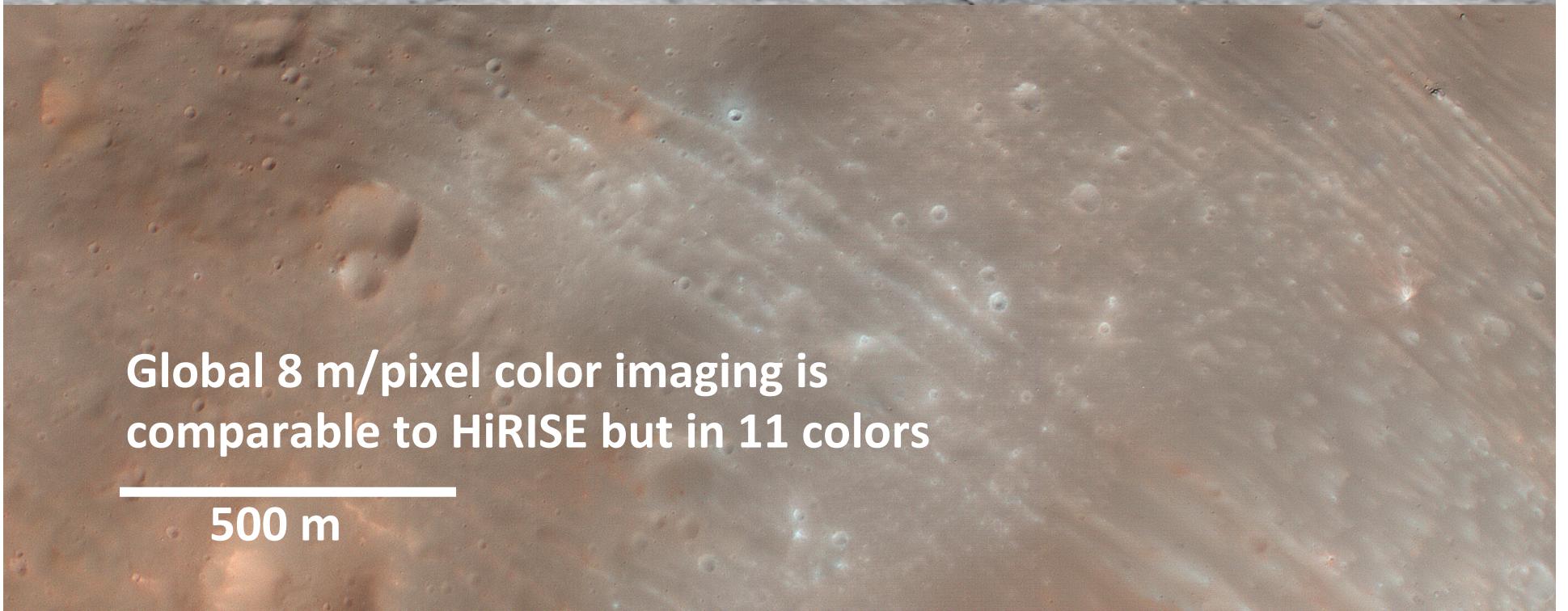
**Non-Keplerian orbits around Phobos cover a range of illuminations over 2.5 months, for global stereo and color imaging.**



**Global 1 m/pixel stereo imaging is  
comparable to best from NEAR**

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100 m



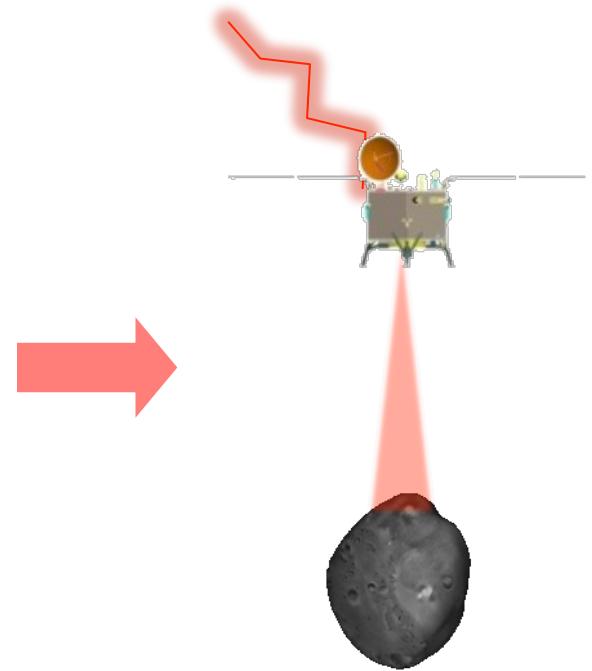
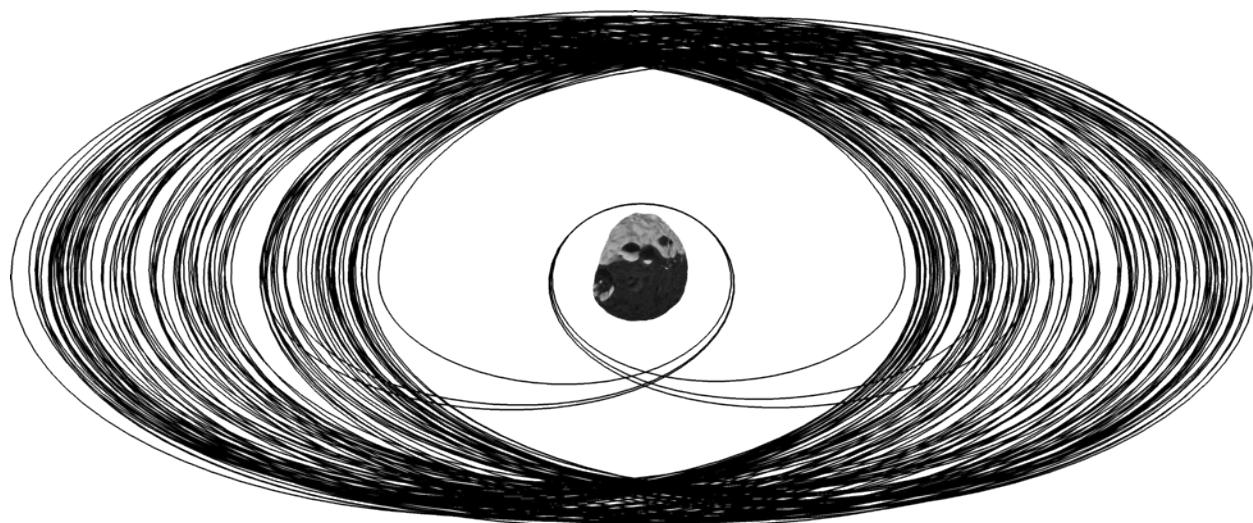
**Global 8 m/pixel color imaging is  
comparable to HiRISE but in 11 colors**

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500 m

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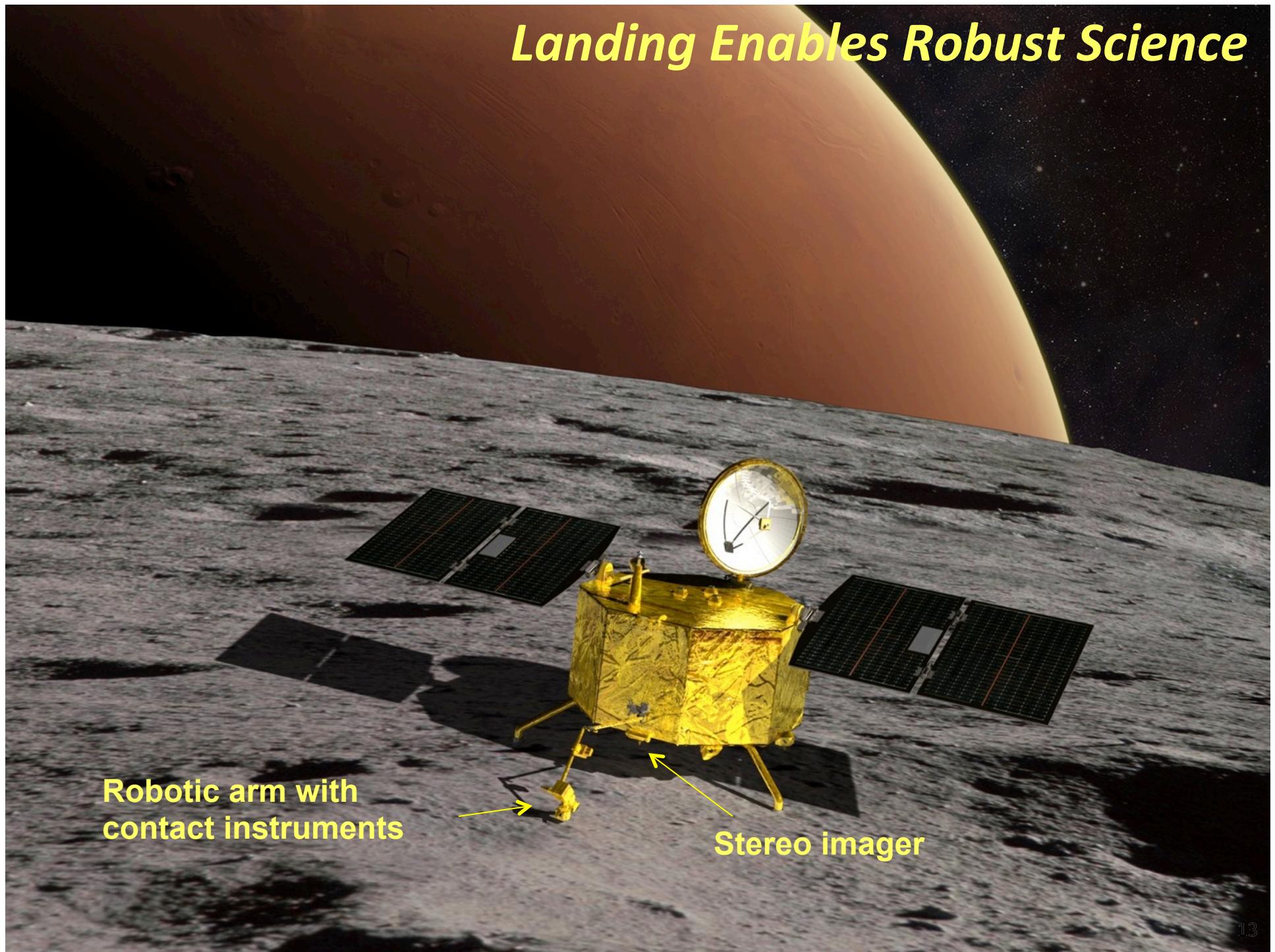
## *Mission Profile: Phobos Low Flyovers & Landing*



**2-km altitude flyovers  
provide 5 cm/pixel high-res  
and 40 cm/pixel color stereo  
images**

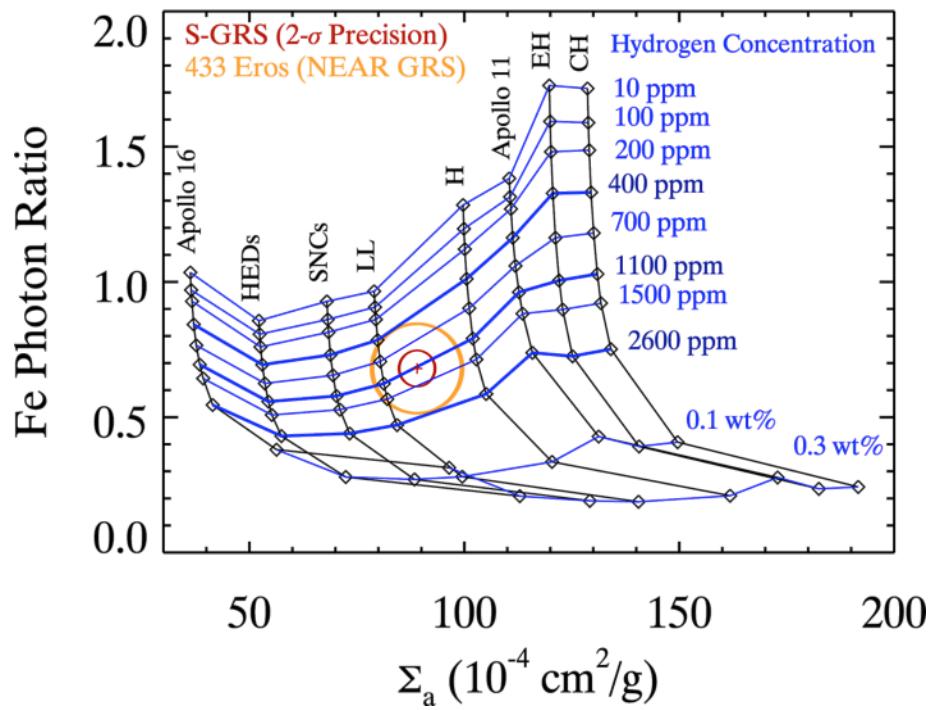
**In Oct 2024 MERLIN navigates to landing  
in a small, targeted ellipse**

# *Landing Enables Robust Science*

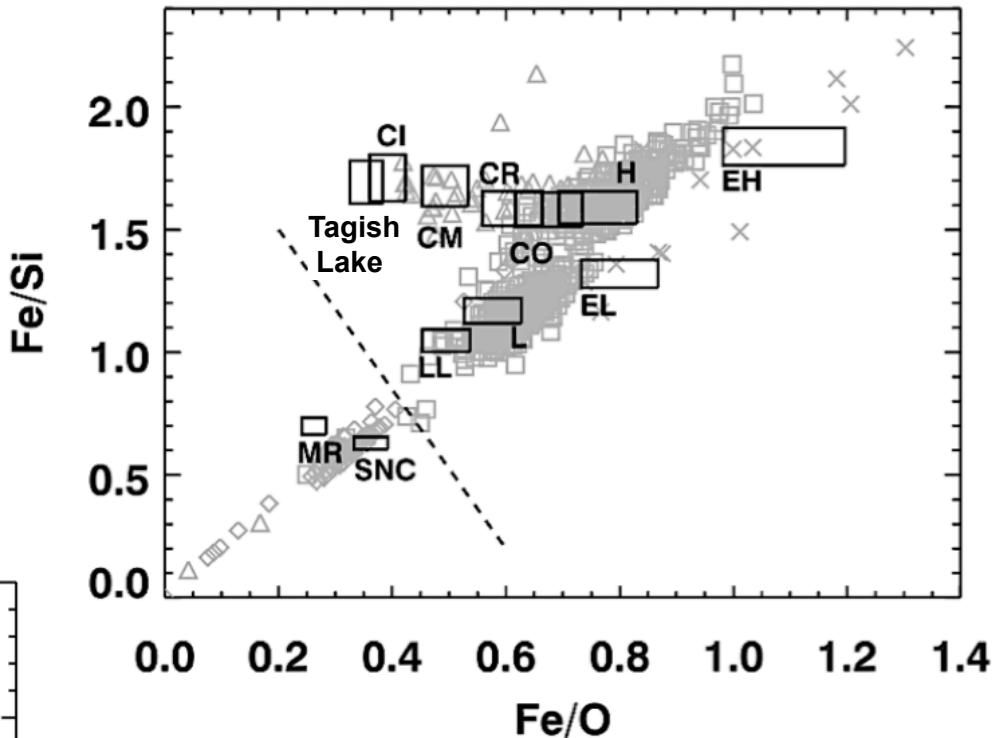


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- Major elements and C are measured to 10's cm depth
- Distinguishes major compositional types

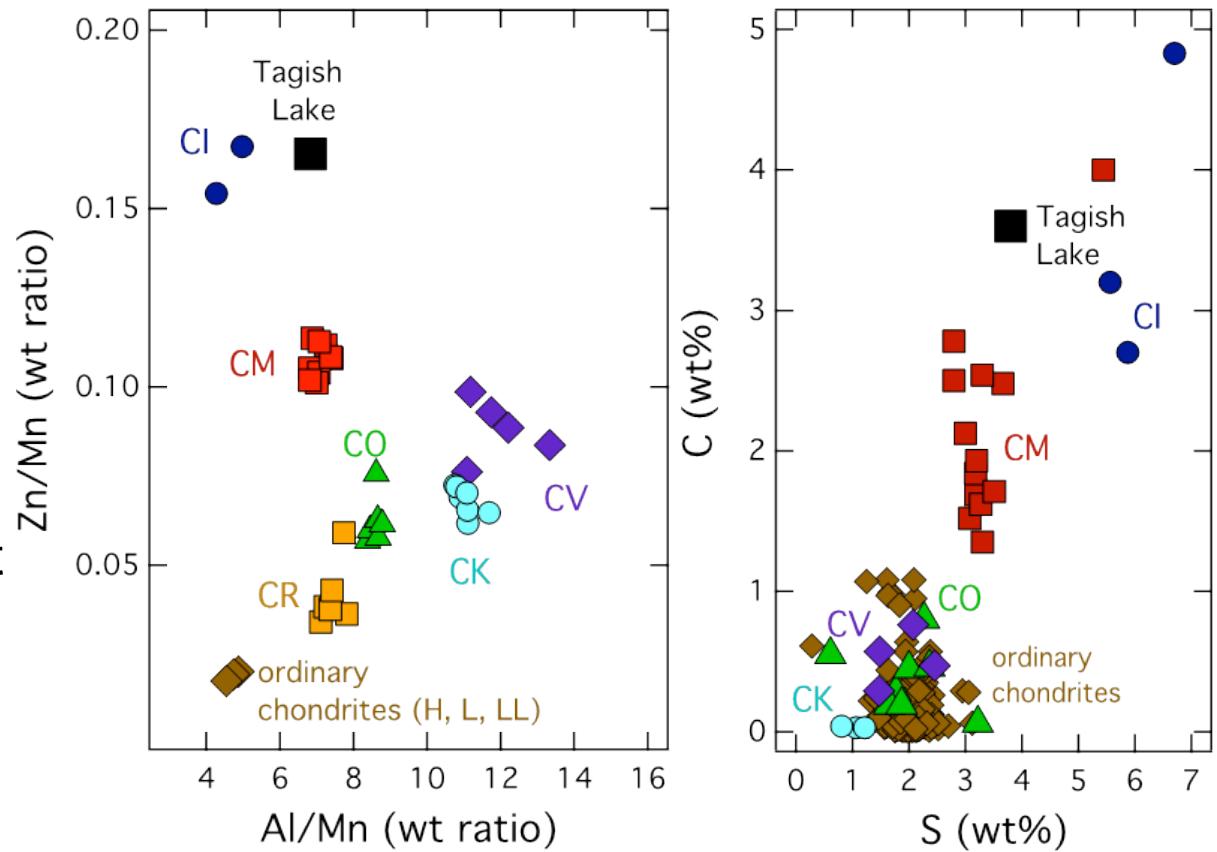


## Gamma-ray Spectrometer



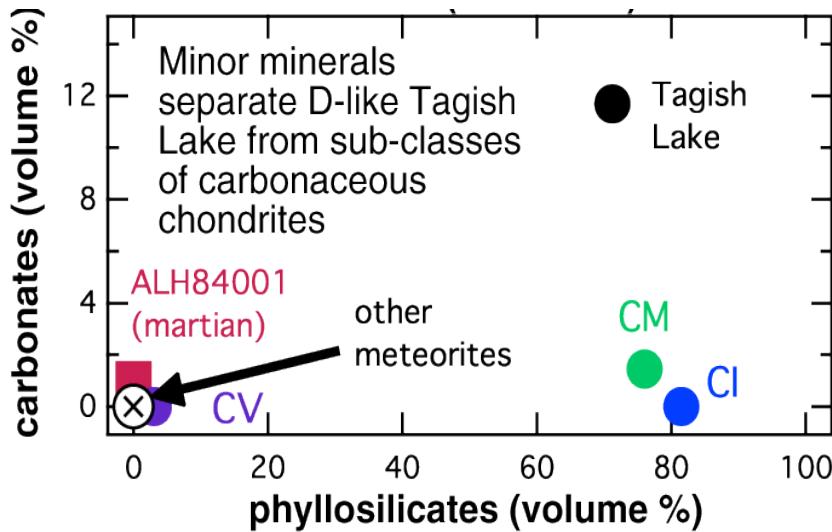
- Gamma-rays support “indirect neutron spectroscopy” to detect H to 100's ppm  
[Peplowski et al. 2015]

- Major and minor elements are measured in top 10's  $\mu\text{m}$
- Discriminates among closely similar analog compositions
- Comparison of volatile K, S with  $\gamma$ -ray results at depth constrains chemical effects of space weathering

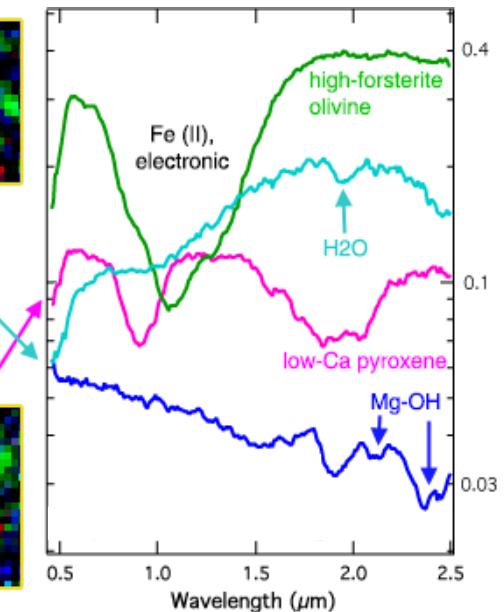
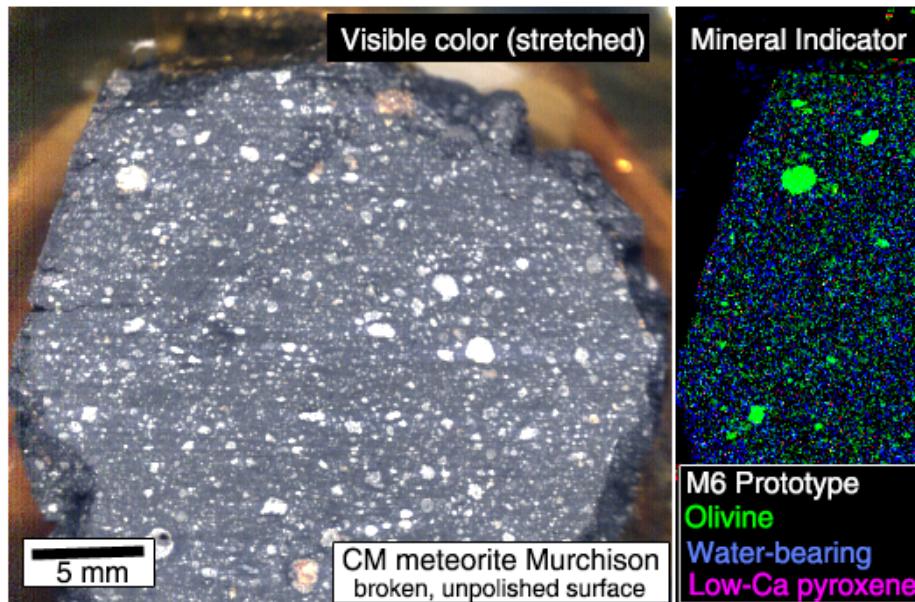


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## Microscopic Imaging Spectrometer



- Analog materials also have differing abundances of major and minor minerals, most of which are “lost” in spectra of large areas
- Instrument is prototyped and lab-tested
- Test results demonstrate that point counts of mineral grains test & corroborate interpretations from elemental measurements



## *MERLIN Accomplishments*

- First U.S. dedicated small-body lander
- First *in situ* exploration of Mars' moons
- First mission to a D-type body
- Closes strategic knowledge gaps for human exploration of the Mars system

